Measurement of associated production of vector bosons and top quark-antiquark pairs in pp collisions at $\sqrt{s} = 7$ TeV

S. Chatrchyan *et al.**
(CMS Collaboration)

(Received 13 March 2013; published 25 April 2013)

The first measurement of vector-boson production associated with a top quark-antiquark pair in proton-proton collisions at $\sqrt{s} = 7$ TeV is presented. The results are based on a data set corresponding to an integrated luminosity of 5.0 fb^{-1}, recorded by the CMS detector at the LHC in 2011. The measurement is performed in two independent channels through a trilepton analysis of $t\bar{t}Z$ events and a same-sign dilepton analysis of $t\bar{t}V$ ($V = W$ or Z) events. In the trilepton channel a direct measurement of the $t\bar{t}Z$ cross section $\sigma_{t\bar{t}Z} = 0.28^{+0.14}_{-0.11}\,(\mathrm{stat})^{+0.06}_{-0.03}\,(\mathrm{syst})$ pb is obtained. In the dilepton channel a measurement of the $t\bar{t}V$ cross section yields $\sigma_{t\bar{t}V} = 0.43^{+0.17}_{-0.15}\,(\mathrm{stat})^{+0.09}_{-0.07}\,(\mathrm{syst})$ pb. These measurements have a significance, respectively, of 3.3 and 3.0 standard deviations from the background hypotheses and are compatible, within uncertainties, with the corresponding next-to-leading order predictions of $0.137^{+0.012}_{-0.016}$ and $0.306^{+0.031}_{-0.053}$ pb.

DOI: 10.1103/PhysRevLett.110.172002 PACS numbers: 14.65.Ha, 13.85.Qk, 14.70.−e

Although the top quark was discovered more than 15 years ago [1,2], many of its properties have not yet been fully investigated. In particular, most of its couplings have never been directly measured. The large value of its mass indicates that the top quark could play a special role in the context of electroweak symmetry breaking. Extensions of the standard model (SM), such as technicolor or other scenarios with a strongly coupled Higgs sector, could alter the top-quark couplings. A measurement of the production of a top-quark pair in association with vector bosons is a key test of the validity of the SM at the TeV scale. In Fig. 1 the most important leading-order Feynman diagrams for $t\bar{t}W$ and $t\bar{t}Z$ production in proton-proton collisions are shown. The current estimate of the cross section for these processes is based on quantum chromodynamics (QCD) calculations at next-to-leading order (NLO), which yield $0.169^{+0.029}_{-0.051}$ pb [3] for $t\bar{t}W$ production, and $0.137^{+0.012}_{-0.016}$ pb [4] for $t\bar{t}Z$ production.

In this Letter, the first measurement of the cross section for associated production of a vector boson and a $t\bar{t}$ pair is presented. Two analyses are conducted: one based on trilepton signatures produced in $t\bar{t}Z$ decays, and one based on same-sign dilepton signatures produced by $t\bar{t}V$ events (with $V = W$ or Z).

This measurement uses data from proton-proton collisions, produced at a center-of-mass energy of 7 TeV, corresponding to an integrated luminosity of 5.0 ± 0.1 fb^{-1} [5]. The data were collected by the Compact Muon Solenoid (CMS) detector at the Large Hadron Collider (LHC) in 2011. As the signal would appear as an excess over a background of similar size, the background estimation is a focus of the analysis. The majority of background contributions are estimated using the data, while the remaining background processes are estimated using Monte Carlo (MC) simulations. Simulated MC event samples are generated using the MADGRAPH 5.1.3.30 event generator [6], interfaced with PYTHIA 6.4 [7] for parton showering. The same generator chain is used for signal events. A GEANT4-based [8] simulation of the response of the CMS detector is used for both signal and background events. These events are processed with the same reconstruction algorithms as the data. Simulated event yields are scaled to the integrated luminosity in the data using cross section calculations to the highest order available, taking into account the trigger and reconstruction efficiencies determined from the data. In addition, the simulated distribution of the number of simultaneous proton-proton collisions within the same bunch crossing (pileup) is reweighted to match the one observed in the data.

A detailed description of the CMS detector can be found elsewhere [9]. Its central feature is a 3.8 T superconducting solenoid of 6 m internal diameter. Within its field volume are the silicon tracker, the crystal electromagnetic calorimeter (ECAL), and the brass and scintillator sampling hadron calorimeter. The muon system, composed of drift

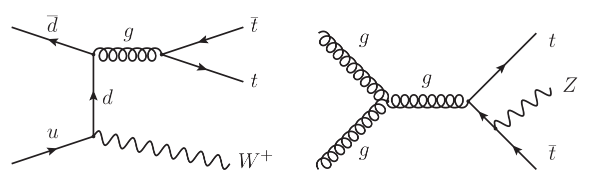

FIG. 1. Most important leading-order Feynman diagrams for $t\bar{t}W$ and $t\bar{t}Z$ production in proton-proton collisions. The charge conjugate of the diagrams shown is implied.

*Full author list given at the end of the article.

tubes, cathode strip chambers, and resistive-plate chambers, is installed outside the solenoid, embedded in the steel return yoke. CMS uses a right-handed coordinate system, with the origin at the nominal interaction point, the x axis pointing to the center of the LHC, the y axis pointing up (perpendicular to the LHC plane), and the z axis along the counterclockwise-beam direction. The polar angle θ is measured from the positive z axis and the azimuthal angle ϕ is measured in the x-y plane. The pseudorapidity η is defined as $-\ln[\tan(\theta/2)]$.

Muons [10] are measured with the combination of the tracker and the muon system, in the pseudorapidity range $|\eta| < 2.4$. Electrons [11] are detected as tracks in the tracker pointing to energy clusters in the ECAL up to $|\eta| = 2.5$. Both muons and electrons are required to have a momentum transverse to the beam axis, p_T, greater than 20 GeV. Both the p_T and η requirements are consistent with those employed in the online trigger selection, where the presence of two isolated charged leptons, either electrons or muons, in any flavor combination, is required to accept the events.

The full details of electron and muon identification criteria are described elsewhere [12]. Isolation requirements on lepton candidates are enforced by measuring the additional detector activity in a surrounding cone of $\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} < 0.3$, where $\Delta\eta$ and $\Delta\phi$ are the differences in pseudorapidity and in azimuthal angle, measured in radians, respectively. For muons the total sum of the transverse momenta of the additional reconstructed tracks and of the energy in the calorimeters in the surrounding cone is required to be less than 15% of the muon transverse momentum in the trilepton channel and 5% in the dilepton channel. Electron isolation requirements are similar but vary depending on the shape of the electron shower. To minimize the contribution of lepton candidates arising from jet misidentification, tighter isolation and identification requirements are employed in the dilepton channels.

Jets are reconstructed with a particle-flow (PF) algorithm [13], a global event reconstruction technique which optimally combines the information of all subdetectors to reconstruct the particles produced in a collision. Reconstructed particle candidates are clustered to form PF jets with the anti-k_T algorithm [14] with a distance parameter of 0.5. The jet energy resolution is typically 15% at 10 GeV and 8% at 100 GeV. Jets are required to be inside the tracker acceptance ($|\eta| < 2.4$), to increase the reconstruction efficiency, and the precision of the energy measurement using PF techniques. Jet energy corrections are applied to account for the nonlinear response of the calorimeters to the particle energies and other instrumental effects. These corrections are based on *in situ* measurements using dijet and γ + jet data samples [15]. Pileup activity has an effect on jet reconstruction by contributing additional particles to the reconstructed jets. The average energy density due to pileup is evaluated in each event and the corresponding energy is subtracted from each jet [16]. A jet identification requirement, primarily based on the energy balance between charged and neutral hadrons in a jet, is applied to remove misidentified jets. Jets are required to have $p_T > 20$ GeV.

To identify jets originating from the hadronization of bottom quarks, a b-tagging algorithm [17] is employed. The algorithm identifies jets from b-hadron decays by requiring at least two tracks to have significant impact parameters with respect to the primary interaction vertex. This tagger is used here with two operating points: the *loose* point corresponds to an efficiency for jets originating from b quarks of about 80% and a misidentification probability for jets from light quarks and gluons of 10%, while the *medium* operating point provides an efficiency for b jets of about 65% and a misidentification probability of about 1%.

In the trilepton analysis, events originating from the process

$$pp \to t\bar{t}Z \to (t \to b\ell^{\pm}\nu)(t \to bjj)(Z \to \ell^{\pm}\ell^{\mp})$$
$$(\text{with } \ell = e \text{ or } \mu) \tag{1}$$

are selected if they contain two same-flavor, opposite-charge leptons (electrons or muons) with $p_T > 20$ GeV, where the dilepton system must have an invariant mass between 81 and 101 GeV and $p_T > 35$ GeV. The presence of a third lepton with $p_T > 10$ GeV and at least three jets, two of which are positively b-tagged (one medium and one loose tag), is required, and the scalar sum of the p_T of all selected jets (H_T) is required to be larger than 120 GeV. These selection requirements have been chosen by optimizing the expected significance of the measurement.

The main background contributions in this analysis are dilepton events from the Drell-Yan process and from $t\bar{t}$ events, where a third lepton is reconstructed from hadronization products, and WZ events where both vector bosons decay to leptons. To determine the background contributions from the data, event samples with less stringent requirements are used. Dilepton $e\mu$ events that satisfy only the lepton p_T and jet multiplicity requirements are dominated by top-quark pair production and are used to control the normalization of the $t\bar{t}$ simulation. A normalization factor of 1.05 ± 0.12 with respect to the NLO cross section is found. The normalization of the Drell-Yan and WZ simulations is determined from a control sample where all the signal requirements are met, except there are no b-tagged jets. The simulations must be normalized by a factor of 1.30 ± 0.13 to correctly predict the number of events in the Z-mass peak in this background-dominated region. Sources of background arising from single-top-quark production mediated through a virtual W boson, in conjunction with a Z boson (tbZ), are taken from the simulation, scaled to the leading-order cross section, and an uncertainty of 50% is assumed on this yield. The contribution from events containing a SM Higgs boson, assuming a mass of 125 GeV, as suggested by recent findings [18,19], has been estimated and found negligible for the trilepton channel.

The total systematic uncertainty is evaluated by assessing the relative change in signal efficiency and background yield in the simulation when varying relevant parameters by 1 standard deviation. The sources of systematic uncertainty include experimental uncertainties such as the background estimate, lepton reconstruction and trigger efficiencies, jet energy scale and resolution, b-tagging efficiency, pileup modeling, and the integrated luminosity. Model uncertainties arising from scale variations of the matrix-element or parton-shower matching scale and the hard-scattering scale Q^2 are also included. The dominant uncertainty comes from the background estimate and amounts to 27% of the background yield; this includes the statistical uncertainty on the number of simulated events and the uncertainty on the background scale factors determined from the data all added in quadrature. All other uncertainties are less than 5%. The signal efficiencies are determined from MC simulations using MADGRAPH. In order to account for any difference due to the NLO predictions, signal efficiencies are also calculated using the POWHEG BOX [20–22] generator. The two simulations differ in their predictions of the signal efficiencies by 13%, and this value is taken as a systematic uncertainty. Systematic uncertainties that affect both signal and background yields are assumed to be fully correlated. The total systematic uncertainty on the measured cross section is 15%.

The event yields after applying the full event selection are shown in Fig. 2. Nine events are observed, compared to a background expectation of 3.2 ± 0.8 events. From the combination of the four decay channels, the presence of a $t\bar{t}Z$ signal is established with a combined significance of 3.3 standard deviations, corresponding to a p value of 4×10^{-4}, as obtained with an asymptotic profile likelihood estimator [23]. The cross section is extracted through a simultaneous measurement performed in the four decay channels, and is measured to be

$$\sigma_{t\bar{t}Z} = 0.28^{+0.14}_{-0.11}\,(\mathrm{stat})^{+0.06}_{-0.03}\,(\mathrm{syst})\ \mathrm{pb}.$$

The measured cross section is found to be compatible, within uncertainties, with the NLO prediction of $0.137^{+0.012}_{-0.016}$ pb [4]. A comparison of the observed and predicted distributions for several kinematic variables is available in the Supplemental Material [24].

The same-sign dilepton analysis searches for events with the following decay chains:

$$pp \to t\bar{t}W \to (t \to b\ell^\pm\nu)(t \to bjj)(W \to \ell^\pm\nu);$$
$$pp \to t\bar{t}Z \to (t \to b\ell^\pm\nu)(t \to bjj)(Z \to \ell^\pm\ell^\mp)$$
$$(\text{with } \ell = e \text{ or } \mu).$$

The final set of selection criteria for the dilepton channel requires the presence of two same-sign leptons, one with

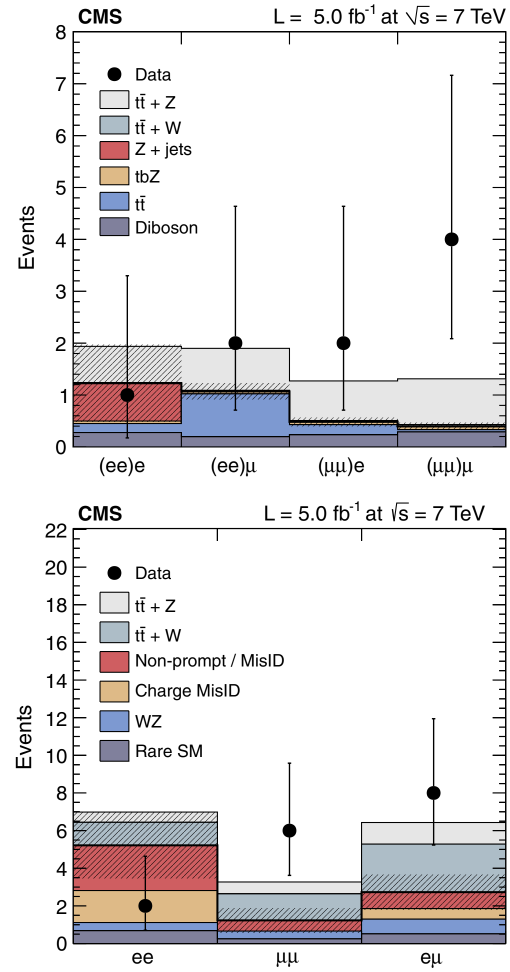

FIG. 2 (color online). Event yields after final selection requirements, separated in lepton flavor channels for the trilepton (top) and same-sign dilepton (bottom) analyses. The expected contributions from signal and background processes are shown, and the uncertainty on the estimated background yield is superimposed with a grey hashed band.

$p_T > 55$ and the other with $p_T > 30$ GeV, and a dilepton invariant mass greater than 8 GeV, at least three jets with $p_T > 20$ GeV of which at least one is b-tagged by the medium operating point, and $H_T > 100$ GeV. These selection requirements have been chosen by optimizing the expected significance of the signal excess. To make this data sample statistically independent of the data selected for the trilepton channel, events passing the trilepton selection are removed.

The benefit of searching for same-sign dilepton events is that SM processes containing two prompt same-sign leptons in the final state have very small cross sections. The background processes considered here include diboson production (WZ, ZZ, $W\gamma$, $Z\gamma$, $W^\pm W^\pm$), tbZ, triboson production, and production of vector-boson pairs from double-parton scattering. Yields from these processes are taken directly from the simulation and scaled to NLO predictions whenever available.

The dominant background contributions originate from nonprompt leptons or misreconstruction effects: pions in jets or decay products of heavy-flavor mesons may give rise to nonprompt lepton candidates; charge misidentification in events with opposite-sign lepton pairs results in same-sign events. These background rates are determined from control regions in the data using techniques that determine the prompt and nonprompt lepton misidentification rates from QCD dijet and $Z \to \ell\ell$ event samples [25]. The result is an estimate, fully based on control samples in the data, of backgrounds with one or more lepton candidates that are not reconstructed from a prompt final-state lepton. These include semileptonic $t\bar{t}$ decays, Drell-Yan events with hard jet production, and QCD multijet production.

The background estimate due to charge misidentification of one of the leptons is obtained from the number of opposite-sign dilepton events in the signal region and the probability to wrongly measure the charge of a lepton. This probability is negligible for muons, but considerable for electrons. From the fraction of same-sign events in a control region dominated by Z decay, the electron charge misidentification probability is measured to be 0.02% (0.3%) in the barrel (endcap) region of the detector.

Systematic uncertainties relative to experimental measurements or model uncertainties are evaluated in a similar manner as in the trilepton channel and are expressed in terms of uncertainties on the signal efficiency or the background yield. Uncertainties on the background prediction are quantified differently for each of the background yield estimates: a 50% uncertainty is assigned to the estimate of processes with nonprompt leptons; the uncertainty on charge misidentification backgrounds is driven by the uncertainty on the measured single-lepton charge misidentification probability and amounts to about 20%; the uncertainty on WZ production is taken from the CMS cross section measurement and is equal to 20%; for all the other SM processes taken from simulation, most of which have not been measured yet, an uncertainty of 50% is assigned. Similar to the trilepton analysis, the uncertainty of the signal efficiency is estimated to be 13%. All uncertainties that affect both signal and background yields are assumed to be fully correlated, whereas background prediction uncertainties are uncorrelated. The total systematic uncertainty in the dilepton channel is 15%. The contribution from a SM Higgs boson with a mass of 125 GeV to the same-sign dilepton sample is estimated to be as large as 0.8 events. The majority of these events originate from Higgs boson production in associated production with $t\bar{t}$ pairs, in conjunction with the decay channels $H \to WW$ and $H \to \tau\tau$. This contribution is not included in the background estimation for this analysis, as doing so would assume a degree of knowledge about the SM Higgs boson that has not been verified yet.

Signal and background event yields are obtained as shown in Fig. 2. A total of 16 events is selected in the data, compared to an expected background contribution of 9.2 ± 2.6 events. The presence of a $t\bar{t}V$ ($V = W$ or Z) signal is established with a significance equivalent to 3.0 standard deviations and a corresponding p value of 0.002, as computed by multiplying the likelihoods of the three decay channels with an asymptotic profile likelihood estimator. The combined cross section, as measured simultaneously from the three channels, is

$$\sigma_{t\bar{t}V} = 0.43^{+0.17}_{-0.15}\,(\text{stat})^{+0.09}_{-0.07}\,(\text{syst})\text{ pb}.$$

The measured cross section is compatible with the NLO prediction of $0.306^{+0.031}_{-0.053}$ pb. A comparison of the observed and predicted distributions for several kinematic variables is available in the Supplemental Material [24].

In summary, the first measurement of the cross section of vector-boson production associated with a top quark-antiquark pair at $\sqrt{s} = 7$ TeV has been presented. In the trilepton channel a direct measurement of the $t\bar{t}Z$ cross section $\sigma_{t\bar{t}Z} = 0.28^{+0.14}_{-0.11}\,(\text{stat})^{+0.06}_{-0.03}\,(\text{syst})$ pb is obtained, with a significance of 3.3 standard deviations from the background hypothesis. In the dilepton channel a measurement of the $t\bar{t}V$ process yields $\sigma_{t\bar{t}V} = 0.43^{+0.17}_{-0.15}\,(\text{stat})^{+0.09}_{-0.07}\,(\text{syst})$ pb, with a significance of 3.0 standard deviations from the background hypothesis. Both cross section measurements are compatible with the NLO predictions. These results are summarized in Fig. 3.

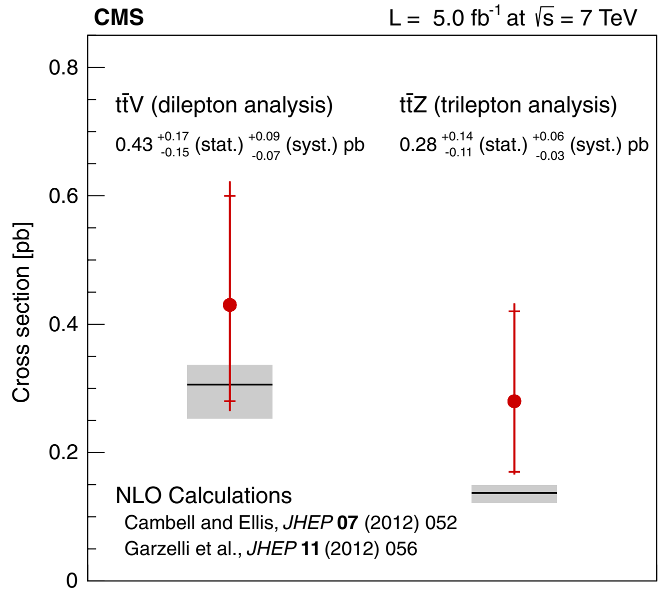

FIG. 3 (color online). Measurements of the $t\bar{t}Z$ and $t\bar{t}V$ production cross sections, in the same-sign dilepton (left) and trilepton channel (right), respectively. The measurements are compared to the NLO calculations (horizontal black lines) and their uncertainty (grey bands). Internal error bars for the measurements represent the statistical component of the uncertainty.

We congratulate our colleagues in the CERN accelerator departments for the excellent performance of the LHC and thank the technical and administrative staffs at CERN and at other CMS institutes for their contributions to the success of the CMS effort. In addition, we gratefully acknowledge the computing centers and personnel of the Worldwide LHC Computing Grid for delivering so effectively the computing infrastructure essential to our analyses. Finally, we acknowledge the enduring support for the construction and operation of the LHC and the CMS detector provided by the following funding agencies: BMWF and FWF (Austria); FNRS and FWO (Belgium); CNPq, CAPES, FAPERJ, and FAPESP (Brazil); MEYS (Bulgaria); CERN; CAS, MoST, and NSFC (China); COLCIENCIAS (Colombia); MSES (Croatia); RPF (Cyprus); MoER, SF0690030s09,and ERDF (Estonia); Academy of Finland, MEC, and HIP (Finland); CEA and CNRS/IN2P3 (France); BMBF, DFG, and HGF (Germany); GSRT (Greece); OTKA and NKTH (Hungary); DAE and DST (India); IPM (Iran); SFI (Ireland); INFN (Italy); NRF and WCU (Republic of Korea); LAS (Lithuania); CINVESTAV, CONACYT, SEP, and UASLP-FAI (Mexico); MSI (New Zealand); PAEC (Pakistan); MSHE and NSC (Poland); FCT (Portugal); JINR (Armenia, Belarus, Georgia, Ukraine, Uzbekistan); MON, RosAtom, RAS, and RFBR (Russia); MSTD (Serbia); SEIDI and CPAN (Spain); Swiss Funding Agencies (Switzerland); NSC (Taipei); ThEPCenter, IPST and NSTDA (Thailand); TUBITAK and TAEK (Turkey); NASU (Ukraine); STFC (United Kingdom); DOE and NSF (USA).

[1] F. Abe *et al.* (CDF Collaboration), Phys. Rev. Lett. **74**, 2626 (1995).
[2] S. Abachi *et al.* (D0 Collaboration), Phys. Rev. Lett. **74**, 2632 (1995).
[3] J. M. Campbell and R. K. Ellis, J. High Energy Phys. 07 (2012) 052.
[4] M. V. Garzelli, A. Kardos, C. G. Papadopoulos, and Z. Trocsanyi, J. High Energy Phys. 11 (2012) 056.
[5] CMS Collaboration, CMS Physics Analysis Summary, Report No. CMS-PAS-SMP-12-008, 2012, http://cds.cern.ch/record/1434360.
[6] J. Alwall, M. Herquet, F. Maltoni, O. Mattelaer, and T. Stelzer, J. High Energy Phys. 06 (2011) 128.
[7] T. Sjöstrand, S. Mrenna, and P. Z. Skands, J. High Energy Phys. 05 (2006) 026.
[8] S. Agostinelli *et al.* (GEANT4 Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[9] CMS Collaboration, JINST **3**, S08004 (2008).
[10] CMS Collaboration, JINST **7**, P10002 (2012).
[11] CMS Collaboration, CMS Physics Analysis Summary, Report No. CMS-PAS-EGM-10-004, 2010, http://cds.cern.ch/record/1299116.
[12] CMS Collaboration, J. High Energy Phys. 01 (2011) 080.
[13] CMS Collaboration, CMS Physics Analysis Summary, Report No. CMS-PAS-PFT-09-001, 2009, http://cds.cern.ch/record/1194487.
[14] M. Cacciari, G. P. Salam, and G. Soyez, J. High Energy Phys. 04 (2008) 063.
[15] CMS Collaboration, JINST **6**, P11002 (2011).
[16] M. Cacciari, G. P. Salam, and G. Soyez, J. High Energy Phys. 04 (2008) 005.
[17] CMS Collaboration, arXiv:1211.4462.
[18] CMS Collaboration, Phys. Lett. B **716**, 30 (2012).
[19] ATLAS Collaboration, Phys. Lett. B **716**, 1 (2012).
[20] P. Nason, J. High Energy Phys. 11 (2004) 040.
[21] S. Frixione, P. Nason, and C. Oleari, J. High Energy Phys. 11 (2007) 070.
[22] S. Alioli, P. Nason, C. Oleari, and E. Re, J. High Energy Phys. 06 (2010) 043.
[23] W. A. Rolke, A. M. Lopez, and J. Conrad, Nucl. Instrum. Methods Phys. Res., Sect. A **551**, 493 (2005).
[24] See Supplemental Material at http://link.aps.org/supplemental/10.1103/PhysRevLett.110.172002 for observed and predicted distributions of several kinematic variables in the final selection.
[25] CMS Collaboration, Phys. Rev. Lett. **109**, 071803 (2012).

S. Chatrchyan,[1] V. Khachatryan,[1] A. M. Sirunyan,[1] A. Tumasyan,[1] W. Adam,[2] E. Aguilo,[2] T. Bergauer,[2] M. Dragicevic,[2] J. Erö,[2] C. Fabjan,[2,b] M. Friedl,[2] R. Frühwirth,[2,b] V. M. Ghete,[2] N. Hörmann,[2] J. Hrubec,[2] M. Jeitler,[2,b] W. Kiesenhofer,[2] V. Knünz,[2] M. Krammer,[2,b] I. Krätschmer,[2] D. Liko,[2] I. Mikulec,[2] M. Pernicka,[2,a] D. Rabady,[2,c] B. Rahbaran,[2] C. Rohringer,[2] H. Rohringer,[2] R. Schöfbeck,[2] J. Strauss,[2] A. Taurok,[2] W. Waltenberger,[2] C.-E. Wulz,[2,b] V. Mossolov,[3] N. Shumeiko,[3] J. Suarez Gonzalez,[3] S. Alderweireldt,[4] M. Bansal,[4] S. Bansal,[4] T. Cornelis,[4] E. A. De Wolf,[4] X. Janssen,[4] S. Luyckx,[4] L. Mucibello,[4] S. Ochesanu,[4] B. Roland,[4] R. Rougny,[4] M. Selvaggi,[4] H. Van Haevermaet,[4] P. Van Mechelen,[4] N. Van Remortel,[4] A. Van Spilbeeck,[4] F. Blekman,[5] S. Blyweert,[5] J. D'Hondt,[5] R. Gonzalez Suarez,[5] A. Kalogeropoulos,[5] M. Maes,[5] A. Olbrechts,[5] S. Tavernier,[5] W. Van Doninck,[5] P. Van Mulders,[5] G. P. Van Onsem,[5] I. Villella,[5] B. Clerbaux,[6] G. De Lentdecker,[6] V. Dero,[6] A. P. R. Gay,[6] T. Hreus,[6] A. Léonard,[6] P. E. Marage,[6] A. Mohammadi,[6] T. Reis,[6] L. Thomas,[6] C. Vander Velde,[6] P. Vanlaer,[6] J. Wang,[6] V. Adler,[7] K. Beernaert,[7] A. Cimmino,[7] S. Costantini,[7] G. Garcia,[7] M. Grunewald,[7] B. Klein,[7] J. Lellouch,[7] A. Marinov,[7] J. Mccartin,[7] A. A. Ocampo Rios,[7] D. Ryckbosch,[7] M. Sigamani,[7] N. Strobbe,[7] F. Thyssen,[7] M. Tytgat,[7] S. Walsh,[7] E. Yazgan,[7] N. Zaganidis,[7] S. Basegmez,[8] G. Bruno,[8] R. Castello,[8] L. Ceard,[8] C. Delaere,[8] T. du Pree,[8] D. Favart,[8] L. Forthomme,[8] A. Giammanco,[8,d] J. Hollar,[8] V. Lemaitre,[8] J. Liao,[8] O. Militaru,[8] C. Nuttens,[8] D. Pagano,[8] A. Pin,[8] K. Piotrzkowski,[8] J. M. Vizan Garcia,[8] N. Beliy,[9] T. Caebergs,[9]

E. Daubie,[9] G. H. Hammad,[9] G. A. Alves,[10] M. Correa Martins Junior,[10] T. Martins,[10] M. E. Pol,[10] M. H. G. Souza,[10] W. L. Aldá Júnior,[11] W. Carvalho,[11] J. Chinellato,[11] A. Custódio,[11] E. M. Da Costa,[11] D. De Jesus Damiao,[11] C. De Oliveira Martins,[11] S. Fonseca De Souza,[11] H. Malbouisson,[11] M. Malek,[11] D. Matos Figueiredo,[11] L. Mundim,[11] H. Nogima,[11] W. L. Prado Da Silva,[11] A. Santoro,[11] L. Soares Jorge,[11] A. Sznajder,[11] E. J. Tonelli Manganote,[11] A. Vilela Pereira,[11] T. S. Anjos,[12b] C. A. Bernardes,[12b] F. A. Dias,[12a,e] T. R. Fernandez Perez Tomei,[12a] E. M. Gregores,[12b] C. Lagana,[12a] F. Marinho,[12a] P. G. Mercadante,[12b] S. F. Novaes,[12a] Sandra S. Padula,[12a] V. Genchev,[13,c] P. Iaydjiev,[13,c] S. Piperov,[13] M. Rodozov,[13] S. Stoykova,[13] G. Sultanov,[13] V. Tcholakov,[13] R. Trayanov,[13] M. Vutova,[13] A. Dimitrov,[14] R. Hadjiiska,[14] V. Kozhuharov,[14] L. Litov,[14] B. Pavlov,[14] P. Petkov,[14] J. G. Bian,[15] G. M. Chen,[15] H. S. Chen,[15] C. H. Jiang,[15] D. Liang,[15] S. Liang,[15] X. Meng,[15] J. Tao,[15] J. Wang,[15] X. Wang,[15] Z. Wang,[15] H. Xiao,[15] M. Xu,[15] J. Zang,[15] Z. Zhang,[15] C. Asawatangtrakuldee,[16] Y. Ban,[16] Y. Guo,[16] Q. Li,[16] W. Li,[16] S. Liu,[16] Y. Mao,[16] S. J. Qian,[16] D. Wang,[16] L. Zhang,[16] W. Zou,[16] C. Avila,[17] C. A. Carrillo Montoya,[17] J. P. Gomez,[17] B. Gomez Moreno,[17] A. F. Osorio Oliveros,[17] J. C. Sanabria,[17] N. Godinovic,[18] D. Lelas,[18] R. Plestina,[18,f] D. Polic,[18] I. Puljak,[18,c] Z. Antunovic,[19] M. Kovac,[19] V. Brigljevic,[20] S. Duric,[20] K. Kadija,[20] J. Luetic,[20] D. Mekterovic,[20] S. Morovic,[20] L. Tikvica,[20] A. Attikis,[21] M. Galanti,[21] G. Mavromanolakis,[21] J. Mousa,[21] C. Nicolaou,[21] F. Ptochos,[21] P. A. Razis,[21] M. Finger,[22] M. Finger, Jr.,[22] Y. Assran,[23,g] S. Elgammal,[23,h] A. Ellithi Kamel,[23,i] A. M. Kuotb Awad,[23,j] M. A. Mahmoud,[23,j] A. Radi,[23,k,l] M. Kadastik,[24] M. Müntel,[24] M. Murumaa,[24] M. Raidal,[24] L. Rebane,[24] A. Tiko,[24] P. Eerola,[25] G. Fedi,[25] M. Voutilainen,[25] J. Härkönen,[26] A. Heikkinen,[26] V. Karimäki,[26] R. Kinnunen,[26] M. J. Kortelainen,[26] T. Lampén,[26] K. Lassila-Perini,[26] S. Lehti,[26] T. Lindén,[26] P. Luukka,[26] T. Mäenpää,[26] T. Peltola,[26] E. Tuominen,[26] J. Tuominiemi,[26] E. Tuovinen,[26] D. Ungaro,[26] L. Wendland,[26] A. Korpela,[27] T. Tuuva,[27] M. Besancon,[28] S. Choudhury,[28] F. Couderc,[28] M. Dejardin,[28] D. Denegri,[28] B. Fabbro,[28] J. L. Faure,[28] F. Ferri,[28] S. Ganjour,[28] A. Givernaud,[28] P. Gras,[28] G. Hamel de Monchenault,[28] P. Jarry,[28] E. Locci,[28] J. Malcles,[28] L. Millischer,[28] A. Nayak,[28] J. Rander,[28] A. Rosowsky,[28] M. Titov,[28] S. Baffioni,[29] F. Beaudette,[29] L. Benhabib,[29] L. Bianchini,[29] M. Bluj,[29,m] P. Busson,[29] C. Charlot,[29] N. Daci,[29] T. Dahms,[29] M. Dalchenko,[29] L. Dobrzynski,[29] A. Florent,[29] R. Granier de Cassagnac,[29] M. Haguenauer,[29] P. Miné,[29] C. Mironov,[29] I. N. Naranjo,[29] M. Nguyen,[29] C. Ochando,[29] P. Paganini,[29] D. Sabes,[29] R. Salerno,[29] Y. Sirois,[29] C. Veelken,[29] A. Zabi,[29] J.-L. Agram,[30,n] J. Andrea,[30] D. Bloch,[30] D. Bodin,[30] J.-M. Brom,[30] M. Cardaci,[30] E. C. Chabert,[30] C. Collard,[30] E. Conte,[30,n] F. Drouhin,[30,n] J.-C. Fontaine,[30,n] D. Gelé,[30] U. Goerlach,[30] P. Juillot,[30] A.-C. Le Bihan,[30] P. Van Hove,[30] S. Beauceron,[31] N. Beaupere,[31] O. Bondu,[31] G. Boudoul,[31] S. Brochet,[31] J. Chasserat,[31] R. Chierici,[31,c] D. Contardo,[31] P. Depasse,[31] H. El Mamouni,[31] J. Fay,[31] S. Gascon,[31] M. Gouzevitch,[31] B. Ille,[31] T. Kurca,[31] M. Lethuillier,[31] L. Mirabito,[31] S. Perries,[31] L. Sgandurra,[31] V. Sordini,[31] Y. Tschudi,[31] P. Verdier,[31] S. Viret,[31] Z. Tsamalaidze,[32,o] C. Autermann,[33] S. Beranek,[33] B. Calpas,[33] M. Edelhoff,[33] L. Feld,[33] N. Heracleous,[33] O. Hindrichs,[33] R. Jussen,[33] K. Klein,[33] J. Merz,[33] A. Ostapchuk,[33] A. Perieanu,[33] F. Raupach,[33] J. Sammet,[33] S. Schael,[33] D. Sprenger,[33] H. Weber,[33] B. Wittmer,[33] V. Zhukov,[33,p] M. Ata,[34] J. Caudron,[34] E. Dietz-Laursonn,[34] D. Duchardt,[34] M. Erdmann,[34] R. Fischer,[34] A. Güth,[34] T. Hebbeker,[34] C. Heidemann,[34] K. Hoepfner,[34] D. Klingebiel,[34] P. Kreuzer,[34] M. Merschmeyer,[34] A. Meyer,[34] M. Olschewski,[34] K. Padeken,[34] P. Papacz,[34] H. Pieta,[34] H. Reithler,[34] S. A. Schmitz,[34] L. Sonnenschein,[34] J. Steggemann,[34] D. Teyssier,[34] S. Thüer,[34] M. Weber,[34] M. Bontenackels,[35] V. Cherepanov,[35] Y. Erdogan,[35] G. Flügge,[35] H. Geenen,[35] M. Geisler,[35] W. Haj Ahmad,[35] F. Hoehle,[35] B. Kargoll,[35] T. Kress,[35] Y. Kuessel,[35] J. Lingemann,[35,c] A. Nowack,[35] I. M. Nugent,[35] L. Perchalla,[35] O. Pooth,[35] P. Sauerland,[35] A. Stahl,[35] M. Aldaya Martin,[36] I. Asin,[36] N. Bartosik,[36] J. Behr,[36] W. Behrenhoff,[36] U. Behrens,[36] M. Bergholz,[36,q] A. Bethani,[36] K. Borras,[36] A. Burgmeier,[36] A. Cakir,[36] L. Calligaris,[36] A. Campbell,[36] E. Castro,[36] F. Costanza,[36] D. Dammann,[36] C. Diez Pardos,[36] T. Dorland,[36] G. Eckerlin,[36] D. Eckstein,[36] G. Flucke,[36] A. Geiser,[36] I. Glushkov,[36] P. Gunnellini,[36] S. Habib,[36] J. Hauk,[36] G. Hellwig,[36] H. Jung,[36] M. Kasemann,[36] P. Katsas,[36] C. Kleinwort,[36] H. Kluge,[36] A. Knutsson,[36] M. Krämer,[36] D. Krücker,[36] E. Kuznetsova,[36] W. Lange,[36] J. Leonard,[36] W. Lohmann,[36,q] B. Lutz,[36] R. Mankel,[36] I. Marfin,[36] M. Marienfeld,[36] I.-A. Melzer-Pellmann,[36] A. B. Meyer,[36] J. Mnich,[36] A. Mussgiller,[36] S. Naumann-Emme,[36] O. Novgorodova,[36] F. Nowak,[36] J. Olzem,[36] H. Perrey,[36] A. Petrukhin,[36] D. Pitzl,[36] A. Raspereza,[36] P. M. Ribeiro Cipriano,[36] C. Riedl,[36] E. Ron,[36] M. Rosin,[36] J. Salfeld-Nebgen,[36] R. Schmidt,[36,q] T. Schoerner-Sadenius,[36] N. Sen,[36] A. Spiridonov,[36] M. Stein,[36] R. Walsh,[36] C. Wissing,[36] V. Blobel,[37] H. Enderle,[37] J. Erfle,[37] U. Gebbert,[37] M. Görner,[37] M. Gosselink,[37] J. Haller,[37] T. Hermanns,[37] R. S. Höing,[37] K. Kaschube,[37] G. Kaussen,[37] H. Kirschenmann,[37] R. Klanner,[37] J. Lange,[37] T. Peiffer,[37] N. Pietsch,[37] D. Rathjens,[37] C. Sander,[37]

H. Schettler,[37] P. Schleper,[37] E. Schlieckau,[37] A. Schmidt,[37] M. Schröder,[37] T. Schum,[37] M. Seidel,[37] J. Sibille,[37,r] V. Sola,[37] H. Stadie,[37] G. Steinbrück,[37] J. Thomsen,[37] L. Vanelderen,[37] C. Barth,[38] C. Baus,[38] J. Berger,[38] C. Böser,[38] T. Chwalek,[38] W. De Boer,[38] A. Descroix,[38] A. Dierlamm,[38] M. Feindt,[38] M. Guthoff,[38,c] C. Hackstein,[38] F. Hartmann,[38,c] T. Hauth,[38,c] M. Heinrich,[38] H. Held,[38] K. H. Hoffmann,[38] U. Husemann,[38] I. Katkov,[38,p] J. R. Komaragiri,[38] P. Lobelle Pardo,[38] D. Martschei,[38] S. Mueller,[38] Th. Müller,[38] M. Niegel,[38] A. Nürnberg,[38] O. Oberst,[38] A. Oehler,[38] J. Ott,[38] G. Quast,[38] K. Rabbertz,[38] F. Ratnikov,[38] N. Ratnikova,[38] S. Röcker,[38] F.-P. Schilling,[38] G. Schott,[38] H. J. Simonis,[38] F. M. Stober,[38] D. Troendle,[38] R. Ulrich,[38] J. Wagner-Kuhr,[38] S. Wayand,[38] T. Weiler,[38] M. Zeise,[38] G. Anagnostou,[39] G. Daskalakis,[39] T. Geralis,[39] S. Kesisoglou,[39] A. Kyriakis,[39] D. Loukas,[39] I. Manolakos,[39] A. Markou,[39] C. Markou,[39] E. Ntomari,[39] L. Gouskos,[40] T. J. Mertzimekis,[40] A. Panagiotou,[40] N. Saoulidou,[40] I. Evangelou,[41] C. Foudas,[41] P. Kokkas,[41] N. Manthos,[41] I. Papadopoulos,[41] G. Bencze,[42] C. Hajdu,[42] P. Hidas,[42] D. Horvath,[42,s] F. Sikler,[42] V. Veszpremi,[42] G. Vesztergombi,[42,t] A. J. Zsigmond,[42] N. Beni,[43] S. Czellar,[43] J. Molnar,[43] J. Palinkas,[43] Z. Szillasi,[43] J. Karancsi,[44] P. Raics,[44] Z. L. Trocsanyi,[44] B. Ujvari,[44] S. B. Beri,[45] V. Bhatnagar,[45] N. Dhingra,[45] R. Gupta,[45] M. Kaur,[45] M. Z. Mehta,[45] M. Mittal,[45] N. Nishu,[45] L. K. Saini,[45] A. Sharma,[45] J. B. Singh,[45] Ashok Kumar,[46] Arun Kumar,[46] S. Ahuja,[46] A. Bhardwaj,[46] B. C. Choudhary,[46] S. Malhotra,[46] M. Naimuddin,[46] K. Ranjan,[46] P. Saxena,[46] V. Sharma,[46] R. K. Shivpuri,[46] S. Banerjee,[47] S. Bhattacharya,[47] K. Chatterjee,[47] S. Dutta,[47] B. Gomber,[47] Sa. Jain,[47] Sh. Jain,[47] R. Khurana,[47] A. Modak,[47] S. Mukherjee,[47] D. Roy,[47] S. Sarkar,[47] M. Sharan,[47] A. Abdulsalam,[48] D. Dutta,[48] S. Kailas,[48] V. Kumar,[48] A. K. Mohanty,[48,c] L. M. Pant,[48] P. Shukla,[48] T. Aziz,[49] R. M. Chatterjee,[49] S. Ganguly,[49] M. Guchait,[49,u] A. Gurtu,[49,v] M. Maity,[49,w] G. Majumder,[49] K. Mazumdar,[49] G. B. Mohanty,[49] B. Parida,[49] K. Sudhakar,[49] N. Wickramage,[49] S. Banerjee,[50] S. Dugad,[50] H. Arfaei,[51,x] H. Bakhshiansohi,[51] S. M. Etesami,[51,y] A. Fahim,[51,x] M. Hashemi,[51,z] H. Hesari,[51] A. Jafari,[51] M. Khakzad,[51] M. Mohammadi Najafabadi,[51] S. Paktinat Mehdiabadi,[51] B. Safarzadeh,[51,aa] M. Zeinali,[51] M. Abbrescia,[52a,52b] L. Barbone,[52a,52b] C. Calabria,[52a,52b,c] S. S. Chhibra,[52a,52b] A. Colaleo,[52a] D. Creanza,[52a,52c] N. De Filippis,[52a,52c,c] M. De Palma,[52a,52b] L. Fiore,[52a] G. Iaselli,[52a,52c] G. Maggi,[52a,52c] M. Maggi,[52a] B. Marangelli,[52a,52b] S. My,[52a,52c] S. Nuzzo,[52a,52b] N. Pacifico,[52a] A. Pompili,[52a,52b] G. Pugliese,[52a,52c] G. Selvaggi,[52a,52b] L. Silvestris,[52a] G. Singh,[52a,52b] R. Venditti,[52a,52b] P. Verwilligen,[52a] G. Zito,[52a] G. Abbiendi,[53a] A. C. Benvenuti,[53a] D. Bonacorsi,[53a,53b] S. Braibant-Giacomelli,[53a,53b] L. Brigliadori,[53a,53b] P. Capiluppi,[53a,53b] A. Castro,[53a,53b] F. R. Cavallo,[53a] M. Cuffiani,[53a,53b] G. M. Dallavalle,[53a] F. Fabbri,[53a] A. Fanfani,[53a,53b] D. Fasanella,[53a,53b] P. Giacomelli,[53a] C. Grandi,[53a] L. Guiducci,[53a,53b] S. Marcellini,[53a] G. Masetti,[53a] M. Meneghelli,[53a,53b,c] A. Montanari,[53a] F. L. Navarria,[53a,53b] F. Odorici,[53a] A. Perrotta,[53a] F. Primavera,[53a,53b] A. M. Rossi,[53a,53b] T. Rovelli,[53a,53b] G. P. Siroli,[53a,53b] N. Tosi,[53a,53b] R. Travaglini,[53a,53b] S. Albergo,[54a,54b] G. Cappello,[54a,54b] M. Chiorboli,[54a,54b] S. Costa,[54a,54b] R. Potenza,[54a,54b] A. Tricomi,[54a,54b] C. Tuve,[54a,54b] G. Barbagli,[55a] V. Ciulli,[55a,55b] C. Civinini,[55a] R. D'Alessandro,[55a,55b] E. Focardi,[55a,55b] S. Frosali,[55a,55b] E. Gallo,[55a] S. Gonzi,[55a,55b] M. Meschini,[55a] S. Paoletti,[55a] G. Sguazzoni,[55a] A. Tropiano,[55a,55b] L. Benussi,[56] S. Bianco,[56] S. Colafranceschi,[56,bb] F. Fabbri,[56] D. Piccolo,[56] P. Fabbricatore,[57a] R. Musenich,[57a] S. Tosi,[57a,57b] A. Benaglia,[58a] F. De Guio,[58a,58b] L. Di Matteo,[58a,58b,c] S. Fiorendi,[58a,58b] S. Gennai,[58a,c] A. Ghezzi,[58a,58b] M. T. Lucchini,[58a,c] S. Malvezzi,[58a] R. A. Manzoni,[58a,58b] A. Martelli,[58a,58b] A. Massironi,[58a,58b] D. Menasce,[58a] L. Moroni,[58a] M. Paganoni,[58a,58b] D. Pedrini,[58a] S. Ragazzi,[58a,58b] N. Redaelli,[58a] T. Tabarelli de Fatis,[58a,58b] S. Buontempo,[59a] N. Cavallo,[59a,59c] A. De Cosa,[59a,59b,c] O. Dogangun,[59a,59b] F. Fabozzi,[59a,59c] A. O. M. Iorio,[59a,59b] L. Lista,[59a] S. Meola,[59a,59d,cc] M. Merola,[59a] P. Paolucci,[59a,c] P. Azzi,[60a] N. Bacchetta,[60a,c] D. Bisello,[60a,60b] A. Branca,[60a,60b,c] R. Carlin,[60a,60b] P. Checchia,[60a] T. Dorigo,[60a] U. Dosselli,[60a] F. Fanzago,[60a] F. Gasparini,[60a,60b] U. Gasparini,[60a,60b] A. Gozzelino,[60a] K. Kanishchev,[60a,60c] S. Lacaprara,[60a] I. Lazzizzera,[60a,60c] M. Margoni,[60a,60b] A. T. Meneguzzo,[60a,60b] J. Pazzini,[60a,60b] N. Pozzobon,[60a,60b] P. Ronchese,[60a,60b] F. Simonetto,[60a,60b] E. Torassa,[60a] M. Tosi,[60a,60b] S. Vanini,[60a,60b] P. Zotto,[60a,60b] M. Gabusi,[61a,61b] S. P. Ratti,[61a,61b] C. Riccardi,[61a,61b] P. Torre,[61a,61b] P. Vitulo,[61a,61b] M. Biasini,[62a,62b] G. M. Bilei,[62a] L. Fanò,[62a,62b] P. Lariccia,[62a,62b] G. Mantovani,[62a,62b] M. Menichelli,[62a] A. Nappi,[62a,62b,a] F. Romeo,[62a,62b] A. Saha,[62a] A. Santocchia,[62a,62b] A. Spiezia,[62a,62b] S. Taroni,[62a,62b] P. Azzurri,[63a,63c] G. Bagliesi,[63a] J. Bernardini,[63a] T. Boccali,[63a] G. Broccolo,[63a,63c] R. Castaldi,[63a] R. T. D'Agnolo,[63a,63c,c] R. Dell'Orso,[63a] F. Fiori,[63a,63b,c] L. Foà,[63a,63c] A. Giassi,[63a] A. Kraan,[63a] F. Ligabue,[63a,63c] T. Lomtadze,[63a] L. Martini,[63a,dd] A. Messineo,[63a,63b] F. Palla,[63a] A. Rizzi,[63a,63b] A. T. Serban,[63a,ee] P. Spagnolo,[63a] P. Squillacioti,[63a,c] R. Tenchini,[63a] G. Tonelli,[63a,63b] A. Venturi,[63a] P. G. Verdini,[63a] L. Barone,[64a,64b] F. Cavallari,[64a] D. Del Re,[64a,64b] M. Diemoz,[64a] C. Fanelli,[64a,64b] M. Grassi,[64a,64b,c] E. Longo,[64a,64b] P. Meridiani,[64a,c]

F. Micheli,[64a,64b] S. Nourbakhsh,[64a,64b] G. Organtini,[64a,64b] R. Paramatti,[64a] S. Rahatlou,[64a,64b] L. Soffi,[64a,64b] N. Amapane,[65a,65b] R. Arcidiacono,[65a,65c] S. Argiro,[65a,65b] M. Arneodo,[65a,65c] C. Biino,[65a] N. Cartiglia,[65a] S. Casasso,[65a,65b] M. Costa,[65a,65b] N. Demaria,[65a] C. Mariotti,[65a,c] S. Maselli,[65a] E. Migliore,[65a,65b] V. Monaco,[65a,65b] M. Musich,[65a,c] M. M. Obertino,[65a,65c] N. Pastrone,[65a] M. Pelliccioni,[65a] A. Potenza,[65a,65b] A. Romero,[65a,65b] M. Ruspa,[65a,65c] R. Sacchi,[65a,65b] A. Solano,[65a,65b] A. Staiano,[65a] S. Belforte,[66a] V. Candelise,[66a,66b] M. Casarsa,[66a] F. Cossutti,[66a,c] G. Della Ricca,[66a,66b] B. Gobbo,[66a] M. Marone,[66a,66b,c] D. Montanino,[66a,66b] A. Penzo,[66a] A. Schizzi,[66a,66b] T. Y. Kim,[67] S. K. Nam,[67] S. Chang,[68] D. H. Kim,[68] G. N. Kim,[68] D. J. Kong,[68] H. Park,[68] D. C. Son,[68] J. Y. Kim,[69] Zero J. Kim,[69] S. Song,[69] S. Choi,[70] D. Gyun,[70] B. Hong,[70] M. Jo,[70] H. Kim,[70] T. J. Kim,[70] K. S. Lee,[70] D. H. Moon,[70] S. K. Park,[70] Y. Roh,[70] M. Choi,[71] J. H. Kim,[71] C. Park,[71] I. C. Park,[71] S. Park,[71] G. Ryu,[71] Y. Choi,[72] Y. K. Choi,[72] J. Goh,[72] M. S. Kim,[72] E. Kwon,[72] B. Lee,[72] J. Lee,[72] S. Lee,[72] H. Seo,[72] I. Yu,[72] M. J. Bilinskas,[73] I. Grigelionis,[73] M. Janulis,[73] A. Juodagalvis,[73] H. Castilla-Valdez,[74] E. De La Cruz-Burelo,[74] I. Heredia-de La Cruz,[74] R. Lopez-Fernandez,[74] J. Martínez-Ortega,[74] A. Sanchez-Hernandez,[74] L. M. Villasenor-Cendejas,[74] S. Carrillo Moreno,[75] F. Vazquez Valencia,[75] H. A. Salazar Ibarguen,[76] E. Casimiro Linares,[77] A. Morelos Pineda,[77] M. A. Reyes-Santos,[77] D. Krofcheck,[78] A. J. Bell,[79] P. H. Butler,[79] R. Doesburg,[79] S. Reucroft,[79] H. Silverwood,[79] M. Ahmad,[80] M. I. Asghar,[80] J. Butt,[80] H. R. Hoorani,[80] S. Khalid,[80] W. A. Khan,[80] T. Khurshid,[80] S. Qazi,[80] M. A. Shah,[80] M. Shoaib,[80] H. Bialkowska,[81] B. Boimska,[81] T. Frueboes,[81] M. Górski,[81] M. Kazana,[81] K. Nawrocki,[81] K. Romanowska-Rybinska,[81] M. Szleper,[81] G. Wrochna,[81] P. Zalewski,[81] G. Brona,[82] K. Bunkowski,[82] M. Cwiok,[82] W. Dominik,[82] K. Doroba,[82] A. Kalinowski,[82] M. Konecki,[82] J. Krolikowski,[82] M. Misiura,[82] W. Wolszczak,[82] N. Almeida,[83] P. Bargassa,[83] A. David,[83] P. Faccioli,[83] P. G. Ferreira Parracho,[83] M. Gallinaro,[83] J. Seixas,[83] J. Varela,[83] P. Vischia,[83] I. Belotelov,[84] P. Bunin,[84] M. Gavrilenko,[84] I. Golutvin,[84] I. Gorbunov,[84] A. Kamenev,[84] V. Karjavin,[84] G. Kozlov,[84] A. Lanev,[84] A. Malakhov,[84] P. Moisenz,[84] V. Palichik,[84] V. Perelygin,[84] S. Shmatov,[84] V. Smirnov,[84] A. Volodko,[84] A. Zarubin,[84] S. Evstyukhin,[85] V. Golovtsov,[85] Y. Ivanov,[85] V. Kim,[85] P. Levchenko,[85] V. Murzin,[85] V. Oreshkin,[85] I. Smirnov,[85] V. Sulimov,[85] L. Uvarov,[85] S. Vavilov,[85] A. Vorobyev,[85] An. Vorobyev,[85] Yu. Andreev,[86] A. Dermenev,[86] S. Gninenko,[86] N. Golubev,[86] M. Kirsanov,[86] N. Krasnikov,[86] V. Matveev,[86] A. Pashenkov,[86] D. Tlisov,[86] A. Toropin,[86] V. Epshteyn,[87] M. Erofeeva,[87] V. Gavrilov,[87] M. Kossov,[87] N. Lychkovskaya,[87] V. Popov,[87] G. Safronov,[87] S. Semenov,[87] I. Shreyber,[87] V. Stolin,[87] E. Vlasov,[87] A. Zhokin,[87] V. Andreev,[88] M. Azarkin,[88] I. Dremin,[88] M. Kirakosyan,[88] A. Leonidov,[88] G. Mesyats,[88] S. V. Rusakov,[88] A. Vinogradov,[88] A. Belyaev,[89] E. Boos,[89] M. Dubinin,[89,e] L. Dudko,[89] A. Ershov,[89] A. Gribushin,[89] V. Klyukhin,[89] O. Kodolova,[89] I. Lokhtin,[89] A. Markina,[89] S. Obraztsov,[89] M. Perfilov,[89] S. Petrushanko,[89] A. Popov,[89] L. Sarycheva,[89,a] V. Savrin,[89] A. Snigirev,[89] I. Azhgirey,[90] I. Bayshev,[90] S. Bitioukov,[90] V. Grishin,[90,c] V. Kachanov,[90] D. Konstantinov,[90] V. Krychkine,[90] V. Petrov,[90] R. Ryutin,[90] A. Sobol,[90] L. Tourtchanovitch,[90] S. Troshin,[90] N. Tyurin,[90] A. Uzunian,[90] A. Volkov,[90] P. Adzic,[91,ff] M. Djordjevic,[91] M. Ekmedzic,[91] D. Krpic,[91,ff] J. Milosevic,[91] M. Aguilar-Benitez,[92] J. Alcaraz Maestre,[92] P. Arce,[92] C. Battilana,[92] E. Calvo,[92] M. Cerrada,[92] M. Chamizo Llatas,[92] N. Colino,[92] B. De La Cruz,[92] A. Delgado Peris,[92] D. Domínguez Vázquez,[92] C. Fernandez Bedoya,[92] J. P. Fernández Ramos,[92] A. Ferrando,[92] J. Flix,[92] M. C. Fouz,[92] P. Garcia-Abia,[92] O. Gonzalez Lopez,[92] S. Goy Lopez,[92] J. M. Hernandez,[92] M. I. Josa,[92] G. Merino,[92] J. Puerta Pelayo,[92] A. Quintario Olmeda,[92] I. Redondo,[92] L. Romero,[92] J. Santaolalla,[92] M. S. Soares,[92] C. Willmott,[92] C. Albajar,[93] G. Codispoti,[93] J. F. de Trocóniz,[93] H. Brun,[94] J. Cuevas,[94] J. Fernandez Menendez,[94] S. Folgueras,[94] I. Gonzalez Caballero,[94] L. Lloret Iglesias,[94] J. Piedra Gomez,[94] J. A. Brochero Cifuentes,[95] I. J. Cabrillo,[95] A. Calderon,[95] S. H. Chuang,[95] J. Duarte Campderros,[95] M. Felcini,[95,gg] M. Fernandez,[95] G. Gomez,[95] J. Gonzalez Sanchez,[95] A. Graziano,[95] C. Jorda,[95] A. Lopez Virto,[95] J. Marco,[95] R. Marco,[95] C. Martinez Rivero,[95] F. Matorras,[95] F. J. Munoz Sanchez,[95] T. Rodrigo,[95] A. Y. Rodríguez-Marrero,[95] A. Ruiz-Jimeno,[95] L. Scodellaro,[95] I. Vila,[95] R. Vilar Cortabitarte,[95] D. Abbaneo,[96] E. Auffray,[96] G. Auzinger,[96] M. Bachtis,[96] P. Baillon,[96] A. H. Ball,[96] D. Barney,[96] J. F. Benitez,[96] C. Bernet,[96,f] G. Bianchi,[96] P. Bloch,[96] A. Bocci,[96] A. Bonato,[96] C. Botta,[96] H. Breuker,[96] T. Camporesi,[96] G. Cerminara,[96] T. Christiansen,[96] J. A. Coarasa Perez,[96] D. D'Enterria,[96] A. Dabrowski,[96] A. De Roeck,[96] S. De Visscher,[96] S. Di Guida,[96] M. Dobson,[96] N. Dupont-Sagorin,[96] A. Elliott-Peisert,[96] B. Frisch,[96] W. Funk,[96] G. Georgiou,[96] M. Giffels,[96] D. Gigi,[96] K. Gill,[96] D. Giordano,[96] M. Girone,[96] M. Giunta,[96] F. Glege,[96] R. Gomez-Reino Garrido,[96] P. Govoni,[96] S. Gowdy,[96] R. Guida,[96] J. Hammer,[96] M. Hansen,[96] P. Harris,[96] C. Hartl,[96] J. Harvey,[96] B. Hegner,[96] A. Hinzmann,[96] V. Innocente,[96] P. Janot,[96] K. Kaadze,[96] E. Karavakis,[96] K. Kousouris,[96] P. Lecoq,[96] Y.-J. Lee,[96] P. Lenzi,[96] C. Lourenço,[96] N. Magini,[96] T. Mäki,[96] M. Malberti,[96] L. Malgeri,[96] M. Mannelli,[96] L. Masetti,[96] F. Meijers,[96]

S. Mersi,[96] E. Meschi,[96] R. Moser,[96] M. Mulders,[96] P. Musella,[96] E. Nesvold,[96] L. Orsini,[96] E. Palencia Cortezon,[96] E. Perez,[96] L. Perrozzi,[96] A. Petrilli,[96] A. Pfeiffer,[96] M. Pierini,[96] M. Pimiä,[96] D. Piparo,[96] G. Polese,[96] L. Quertenmont,[96] A. Racz,[96] W. Reece,[96] J. Rodrigues Antunes,[96] G. Rolandi,[96,hh] C. Rovelli,[96,ii] M. Rovere,[96] H. Sakulin,[96] F. Santanastasio,[96] C. Schäfer,[96] C. Schwick,[96] I. Segoni,[96] S. Sekmen,[96] A. Sharma,[96] P. Siegrist,[96] P. Silva,[96] M. Simon,[96] P. Sphicas,[96,jj] D. Spiga,[96] A. Tsirou,[96] G. I. Veres,[96,t] J. R. Vlimant,[96] H. K. Wöhri,[96] S. D. Worm,[96,kk] W. D. Zeuner,[96] W. Bertl,[97] K. Deiters,[97] W. Erdmann,[97] K. Gabathuler,[97] R. Horisberger,[97] Q. Ingram,[97] H. C. Kaestli,[97] S. König,[97] D. Kotlinski,[97] U. Langenegger,[97] F. Meier,[97] D. Renker,[97] T. Rohe,[97] F. Bachmair,[98] L. Bäni,[98] P. Bortignon,[98] M. A. Buchmann,[98] B. Casal,[98] N. Chanon,[98] A. Deisher,[98] G. Dissertori,[98] M. Dittmar,[98] M. Donegà,[98] M. Dünser,[98] P. Eller,[98] J. Eugster,[98] K. Freudenreich,[98] C. Grab,[98] D. Hits,[98] P. Lecomte,[98] W. Lustermann,[98] A. C. Marini,[98] P. Martinez Ruiz del Arbol,[98] N. Mohr,[98] F. Moortgat,[98] C. Nägeli,[98,ll] P. Nef,[98] F. Nessi-Tedaldi,[98] F. Pandolfi,[98] L. Pape,[98] F. Pauss,[98] M. Peruzzi,[98] F. J. Ronga,[98] M. Rossini,[98] L. Sala,[98] A. K. Sanchez,[98] A. Starodumov,[98,mm] B. Stieger,[98] M. Takahashi,[98] L. Tauscher,[98,a] A. Thea,[98] K. Theofilatos,[98] D. Treille,[98] C. Urscheler,[98] R. Wallny,[98] H. A. Weber,[98] L. Wehrli,[98] C. Amsler,[99,nn] V. Chiochia,[99] C. Favaro,[99] M. Ivova Rikova,[99] B. Kilminster,[99] B. Millan Mejias,[99] P. Otiougova,[99] P. Robmann,[99] H. Snoek,[99] S. Tupputi,[99] M. Verzetti,[99] Y. H. Chang,[100] K. H. Chen,[100] C. Ferro,[100] C. M. Kuo,[100] S. W. Li,[100] W. Lin,[100] Y. J. Lu,[100] A. P. Singh,[100] R. Volpe,[100] S. S. Yu,[100] P. Bartalini,[101] P. Chang,[101] Y. H. Chang,[101] Y. W. Chang,[101] Y. Chao,[101] K. F. Chen,[101] C. Dietz,[101] U. Grundler,[101] W.-S. Hou,[101] Y. Hsiung,[101] K. Y. Kao,[101] Y. J. Lei,[101] R.-S. Lu,[101] D. Majumder,[101] E. Petrakou,[101] X. Shi,[101] J. G. Shiu,[101] Y. M. Tzeng,[101] X. Wan,[101] M. Wang,[101] B. Asavapibhop,[102] E. Simili,[102] N. Srimanobhas,[102] N. Suwonjandee,[102] A. Adiguzel,[103] M. N. Bakirci,[103,oo] S. Cerci,[103,pp] C. Dozen,[103] I. Dumanoglu,[103] E. Eskut,[103] S. Girgis,[103] G. Gokbulut,[103] E. Gurpinar,[103] I. Hos,[103] E. E. Kangal,[103] T. Karaman,[103] G. Karapinar,[103,qq] A. Kayis Topaksu,[103] G. Onengut,[103] K. Ozdemir,[103] S. Ozturk,[103,rr] A. Polatoz,[103] K. Sogut,[103,ss] D. Sunar Cerci,[103,pp] B. Tali,[103,pp] H. Topakli,[103,oo] L. N. Vergili,[103] M. Vergili,[103] I. V. Akin,[104] T. Aliev,[104] B. Bilin,[104] S. Bilmis,[104] M. Deniz,[104] H. Gamsizkan,[104] A. M. Guler,[104] K. Ocalan,[104] A. Ozpineci,[104] M. Serin,[104] R. Sever,[104] U. E. Surat,[104] M. Yalvac,[104] E. Yildirim,[104] M. Zeyrek,[104] E. Gülmez,[105] B. Isildak,[105,tt] M. Kaya,[105,uu] O. Kaya,[105,uu] S. Ozkorucuklu,[105,vv] N. Sonmez,[105,ww] H. Bahtiyar,[106,xx] E. Barlas,[106] K. Cankocak,[106] Y. O. Günaydin,[106,yy] F. I. Vardarlı,[106] M. Yücel,[106] L. Levchuk,[107] J. J. Brooke,[108] E. Clement,[108] D. Cussans,[108] H. Flacher,[108] R. Frazier,[108] J. Goldstein,[108] M. Grimes,[108] G. P. Heath,[108] H. F. Heath,[108] L. Kreczko,[108] S. Metson,[108] D. M. Newbold,[108,kk] K. Nirunpong,[108] A. Poll,[108] S. Senkin,[108] V. J. Smith,[108] T. Williams,[108] L. Basso,[109,zz] K. W. Bell,[109] A. Belyaev,[109,zz] C. Brew,[109] R. M. Brown,[109] D. J. A. Cockerill,[109] J. A. Coughlan,[109] K. Harder,[109] S. Harper,[109] J. Jackson,[109] B. W. Kennedy,[109] E. Olaiya,[109] D. Petyt,[109] B. C. Radburn-Smith,[109] C. H. Shepherd-Themistocleous,[109] I. R. Tomalin,[109] W. J. Womersley,[109] R. Bainbridge,[110] G. Ball,[110] R. Beuselinck,[110] O. Buchmuller,[110] D. Colling,[110] N. Cripps,[110] M. Cutajar,[110] P. Dauncey,[110] G. Davies,[110] M. Della Negra,[110] W. Ferguson,[110] J. Fulcher,[110] D. Futyan,[110] A. Gilbert,[110] A. Guneratne Bryer,[110] G. Hall,[110] Z. Hatherell,[110] J. Hays,[110] G. Iles,[110] M. Jarvis,[110] G. Karapostoli,[110] M. Kenzie,[110] L. Lyons,[110] A.-M. Magnan,[110] J. Marrouche,[110] B. Mathias,[110] R. Nandi,[110] J. Nash,[110] A. Nikitenko,[110,mm] J. Pela,[110] M. Pesaresi,[110] K. Petridis,[110] M. Pioppi,[110,aaa] D. M. Raymond,[110] S. Rogerson,[110] A. Rose,[110] C. Seez,[110] P. Sharp,[110,a] A. Sparrow,[110] M. Stoye,[110] A. Tapper,[110] M. Vazquez Acosta,[110] T. Virdee,[110] S. Wakefield,[110] N. Wardle,[110] T. Whyntie,[110] M. Chadwick,[111] J. E. Cole,[111] P. R. Hobson,[111] A. Khan,[111] P. Kyberd,[111] D. Leggat,[111] D. Leslie,[111] W. Martin,[111] I. D. Reid,[111] P. Symonds,[111] L. Teodorescu,[111] M. Turner,[111] K. Hatakeyama,[112] H. Liu,[112] T. Scarborough,[112] O. Charaf,[113] S. I. Cooper,[113] C. Henderson,[113] P. Rumerio,[113] A. Avetisyan,[114] T. Bose,[114] C. Fantasia,[114] A. Heister,[114] P. Lawson,[114] D. Lazic,[114] J. Rohlf,[114] D. Sperka,[114] J. St. John,[114] L. Sulak,[114] J. Alimena,[115] S. Bhattacharya,[115] G. Christopher,[115] D. Cutts,[115] Z. Demiragli,[115] A. Ferapontov,[115] A. Garabedian,[115] U. Heintz,[115] S. Jabeen,[115] G. Kukartsev,[115] E. Laird,[115] G. Landsberg,[115] M. Luk,[115] M. Narain,[115] M. Segala,[115] T. Sinthuprasith,[115] T. Speer,[115] R. Breedon,[116] G. Breto,[116] M. Calderon De La Barca Sanchez,[116] M. Caulfield,[116] S. Chauhan,[116] M. Chertok,[116] J. Conway,[116] R. Conway,[116] P. T. Cox,[116] J. Dolen,[116] R. Erbacher,[116] M. Gardner,[116] R. Houtz,[116] W. Ko,[116] A. Kopecky,[116] R. Lander,[116] O. Mall,[116] T. Miceli,[116] R. Nelson,[116] D. Pellett,[116] F. Ricci-Tam,[116] B. Rutherford,[116] M. Searle,[116] J. Smith,[116] M. Squires,[116] M. Tripathi,[116] R. Vasquez Sierra,[116] R. Yohay,[116] V. Andreev,[117] D. Cline,[117] R. Cousins,[117] J. Duris,[117] S. Erhan,[117] P. Everaerts,[117] C. Farrell,[117] J. Hauser,[117] M. Ignatenko,[117] C. Jarvis,[117] G. Rakness,[117] P. Schlein,[117,a] P. Traczyk,[117] V. Valuev,[117] M. Weber,[117] J. Babb,[118] R. Clare,[118] M. E. Dinardo,[118] J. Ellison,[118] J. W. Gary,[118] F. Giordano,[118] G. Hanson,[118] H. Liu,[118] O. R. Long,[118] A. Luthra,[118] H. Nguyen,[118]

S. Paramesvaran,[118] J. Sturdy,[118] S. Sumowidagdo,[118] R. Wilken,[118] S. Wimpenny,[118] W. Andrews,[119] J. G. Branson,[119] G. B. Cerati,[119] S. Cittolin,[119] D. Evans,[119] A. Holzner,[119] R. Kelley,[119] M. Lebourgeois,[119] J. Letts,[119] I. Macneill,[119] B. Mangano,[119] S. Padhi,[119] C. Palmer,[119] G. Petrucciani,[119] M. Pieri,[119] M. Sani,[119] V. Sharma,[119] S. Simon,[119] E. Sudano,[119] M. Tadel,[119] Y. Tu,[119] A. Vartak,[119] S. Wasserbaech,[119,bbb] F. Würthwein,[119] A. Yagil,[119] J. Yoo,[119] D. Barge,[120] R. Bellan,[120] C. Campagnari,[120] M. D'Alfonso,[120] T. Danielson,[120] K. Flowers,[120] P. Geffert,[120] C. George,[120] F. Golf,[120] J. Incandela,[120] C. Justus,[120] P. Kalavase,[120] D. Kovalskyi,[120] V. Krutelyov,[120] S. Lowette,[120] R. Magaña Villalba,[120] N. Mccoll,[120] V. Pavlunin,[120] J. Ribnik,[120] J. Richman,[120] R. Rossin,[120] D. Stuart,[120] W. To,[120] C. West,[120] A. Apresyan,[121] A. Bornheim,[121] J. Bunn,[121] Y. Chen,[121] E. Di Marco,[121] J. Duarte,[121] M. Gataullin,[121] D. Kcira,[121] Y. Ma,[121] A. Mott,[121] H. B. Newman,[121] C. Rogan,[121] M. Spiropulu,[121] V. Timciuc,[121] J. Veverka,[121] R. Wilkinson,[121] S. Xie,[121] Y. Yang,[121] R. Y. Zhu,[121] V. Azzolini,[122] A. Calamba,[122] R. Carroll,[122] T. Ferguson,[122] Y. Iiyama,[122] D. W. Jang,[122] Y. F. Liu,[122] M. Paulini,[122] H. Vogel,[122] I. Vorobiev,[122] J. P. Cumalat,[123] B. R. Drell,[123] W. T. Ford,[123] A. Gaz,[123] E. Luiggi Lopez,[123] J. G. Smith,[123] K. Stenson,[123] K. A. Ulmer,[123] S. R. Wagner,[123] J. Alexander,[124] A. Chatterjee,[124] N. Eggert,[124] L. K. Gibbons,[124] B. Heltsley,[124] W. Hopkins,[124] A. Khukhunaishvili,[124] B. Kreis,[124] N. Mirman,[124] G. Nicolas Kaufman,[124] J. R. Patterson,[124] A. Ryd,[124] E. Salvati,[124] W. Sun,[124] W. D. Teo,[124] J. Thom,[124] J. Thompson,[124] J. Tucker,[124] Y. Weng,[124] L. Winstrom,[124] P. Wittich,[124] D. Winn,[125] S. Abdullin,[126] M. Albrow,[126] J. Anderson,[126] G. Apollinari,[126] L. A. T. Bauerdick,[126] A. Beretvas,[126] J. Berryhill,[126] P. C. Bhat,[126] K. Burkett,[126] J. N. Butler,[126] V. Chetluru,[126] H. W. K. Cheung,[126] F. Chlebana,[126] S. Cihangir,[126] V. D. Elvira,[126] I. Fisk,[126] J. Freeman,[126] Y. Gao,[126] D. Green,[126] O. Gutsche,[126] J. Hanlon,[126] R. M. Harris,[126] J. Hirschauer,[126] B. Hooberman,[126] S. Jindariani,[126] M. Johnson,[126] U. Joshi,[126] B. Klima,[126] S. Kunori,[126] S. Kwan,[126] C. Leonidopoulos,[126,ccc] J. Linacre,[126] D. Lincoln,[126] R. Lipton,[126] J. Lykken,[126] K. Maeshima,[126] J. M. Marraffino,[126] V. I. Martinez Outschoorn,[126] S. Maruyama,[126] D. Mason,[126] P. McBride,[126] K. Mishra,[126] S. Mrenna,[126] Y. Musienko,[126,ddd] C. Newman-Holmes,[126] V. O'Dell,[126] E. Sexton-Kennedy,[126] S. Sharma,[126] W. J. Spalding,[126] L. Spiegel,[126] L. Taylor,[126] S. Tkaczyk,[126] N. V. Tran,[126] L. Uplegger,[126] E. W. Vaandering,[126] R. Vidal,[126] J. Whitmore,[126] W. Wu,[126] F. Yang,[126] J. C. Yun,[126] D. Acosta,[127] P. Avery,[127] D. Bourilkov,[127] M. Chen,[127] T. Cheng,[127] S. Das,[127] M. De Gruttola,[127] G. P. Di Giovanni,[127] D. Dobur,[127] A. Drozdetskiy,[127] R. D. Field,[127] M. Fisher,[127] Y. Fu,[127] I. K. Furic,[127] J. Gartner,[127] J. Hugon,[127] B. Kim,[127] J. Konigsberg,[127] A. Korytov,[127] A. Kropivnitskaya,[127] T. Kypreos,[127] J. F. Low,[127] K. Matchev,[127] P. Milenovic,[127,eee] G. Mitselmakher,[127] L. Muniz,[127] M. Park,[127] R. Remington,[127] A. Rinkevicius,[127] P. Sellers,[127] N. Skhirtladze,[127] M. Snowball,[127] J. Yelton,[127] M. Zakaria,[127] V. Gaultney,[128] S. Hewamanage,[128] L. M. Lebolo,[128] S. Linn,[128] P. Markowitz,[128] G. Martinez,[128] J. L. Rodriguez,[128] T. Adams,[129] A. Askew,[129] J. Bochenek,[129] J. Chen,[129] B. Diamond,[129] S. V. Gleyzer,[129] J. Haas,[129] S. Hagopian,[129] V. Hagopian,[129] M. Jenkins,[129] K. F. Johnson,[129] H. Prosper,[129] V. Veeraraghavan,[129] M. Weinberg,[129] M. M. Baarmand,[130] B. Dorney,[130] M. Hohlmann,[130] H. Kalakhety,[130] I. Vodopiyanov,[130] F. Yumiceva,[130] M. R. Adams,[131] L. Apanasevich,[131] Y. Bai,[131] V. E. Bazterra,[131] R. R. Betts,[131] I. Bucinskaite,[131] J. Callner,[131] R. Cavanaugh,[131] O. Evdokimov,[131] L. Gauthier,[131] C. E. Gerber,[131] D. J. Hofman,[131] S. Khalatyan,[131] F. Lacroix,[131] C. O'Brien,[131] C. Silkworth,[131] D. Strom,[131] P. Turner,[131] N. Varelas,[131] U. Akgun,[132] E. A. Albayrak,[132] B. Bilki,[132,fff] W. Clarida,[132] F. Duru,[132] S. Griffiths,[132] J.-P. Merlo,[132] H. Mermerkaya,[132,ggg] A. Mestvirishvili,[132] A. Moeller,[132] J. Nachtman,[132] C. R. Newsom,[132] E. Norbeck,[132] Y. Onel,[132] F. Ozok,[132,xx] S. Sen,[132] P. Tan,[132] E. Tiras,[132] J. Wetzel,[132] T. Yetkin,[132,hhh] K. Yi,[132] B. A. Barnett,[133] B. Blumenfeld,[133] S. Bolognesi,[133] D. Fehling,[133] G. Giurgiu,[133] A. V. Gritsan,[133] G. Hu,[133] P. Maksimovic,[133] M. Swartz,[133] A. Whitbeck,[133] P. Baringer,[134] A. Bean,[134] G. Benelli,[134] R. P. Kenny Iii,[134] M. Murray,[134] D. Noonan,[134] S. Sanders,[134] R. Stringer,[134] G. Tinti,[134] J. S. Wood,[134] A. F. Barfuss,[135] T. Bolton,[135] I. Chakaberia,[135] A. Ivanov,[135] S. Khalil,[135] M. Makouski,[135] Y. Maravin,[135] S. Shrestha,[135] I. Svintradze,[135] J. Gronberg,[136] D. Lange,[136] F. Rebassoo,[136] D. Wright,[136] A. Baden,[137] B. Calvert,[137] S. C. Eno,[137] J. A. Gomez,[137] N. J. Hadley,[137] R. G. Kellogg,[137] M. Kirn,[137] T. Kolberg,[137] Y. Lu,[137] M. Marionneau,[137] A. C. Mignerey,[137] K. Pedro,[137] A. Peterman,[137] A. Skuja,[137] J. Temple,[137] M. B. Tonjes,[137] S. C. Tonwar,[137] A. Apyan,[138] G. Bauer,[138] J. Bendavid,[138] W. Busza,[138] E. Butz,[138] I. A. Cali,[138] M. Chan,[138] V. Dutta,[138] G. Gomez Ceballos,[138] M. Goncharov,[138] Y. Kim,[138] M. Klute,[138] K. Krajczar,[138,iii] A. Levin,[138] P. D. Luckey,[138] T. Ma,[138] S. Nahn,[138] C. Paus,[138] D. Ralph,[138] C. Roland,[138] G. Roland,[138] M. Rudolph,[138] G. S. F. Stephans,[138] F. Stöckli,[138] K. Sumorok,[138] K. Sung,[138] D. Velicanu,[138] E. A. Wenger,[138] R. Wolf,[138] B. Wyslouch,[138] M. Yang,[138] Y. Yilmaz,[138] A. S. Yoon,[138] M. Zanetti,[138] V. Zhukova,[138] B. Dahmes,[139] A. De Benedetti,[139] G. Franzoni,[139] A. Gude,[139]

J. Haupt,[139] S. C. Kao,[139] K. Klapoetke,[139] Y. Kubota,[139] J. Mans,[139] N. Pastika,[139] R. Rusack,[139] M. Sasseville,[139] A. Singovsky,[139] N. Tambe,[139] J. Turkewitz,[139] L. M. Cremaldi,[140] R. Kroeger,[140] L. Perera,[140] R. Rahmat,[140] D. A. Sanders,[140] E. Avdeeva,[141] K. Bloom,[141] S. Bose,[141] D. R. Claes,[141] A. Dominguez,[141] M. Eads,[141] J. Keller,[141] I. Kravchenko,[141] J. Lazo-Flores,[141] S. Malik,[141] G. R. Snow,[141] A. Godshalk,[142] I. Iashvili,[142] S. Jain,[142] A. Kharchilava,[142] A. Kumar,[142] S. Rappoccio,[142] Z. Wan,[142] G. Alverson,[143] E. Barberis,[143] D. Baumgartel,[143] M. Chasco,[143] J. Haley,[143] D. Nash,[143] T. Orimoto,[143] D. Trocino,[143] D. Wood,[143] J. Zhang,[143] A. Anastassov,[144] K. A. Hahn,[144] A. Kubik,[144] L. Lusito,[144] N. Mucia,[144] N. Odell,[144] R. A. Ofierzynski,[144] B. Pollack,[144] A. Pozdnyakov,[144] M. Schmitt,[144] S. Stoynev,[144] M. Velasco,[144] S. Won,[144] D. Berry,[145] A. Brinkerhoff,[145] K. M. Chan,[145] M. Hildreth,[145] C. Jessop,[145] D. J. Karmgard,[145] J. Kolb,[145] K. Lannon,[145] W. Luo,[145] S. Lynch,[145] N. Marinelli,[145] D. M. Morse,[145] T. Pearson,[145] M. Planer,[145] R. Ruchti,[145] J. Slaunwhite,[145] N. Valls,[145] M. Wayne,[145] M. Wolf,[145] L. Antonelli,[146] B. Bylsma,[146] L. S. Durkin,[146] C. Hill,[146] R. Hughes,[146] K. Kotov,[146] T. Y. Ling,[146] D. Puigh,[146] M. Rodenburg,[146] C. Vuosalo,[146] G. Williams,[146] B. L. Winer,[146] E. Berry,[147] P. Elmer,[147] V. Halyo,[147] P. Hebda,[147] J. Hegeman,[147] A. Hunt,[147] P. Jindal,[147] S. A. Koay,[147] D. Lopes Pegna,[147] P. Lujan,[147] D. Marlow,[147] T. Medvedeva,[147] M. Mooney,[147] J. Olsen,[147] P. Piroué,[147] X. Quan,[147] A. Raval,[147] H. Saka,[147] D. Stickland,[147] C. Tully,[147] J. S. Werner,[147] S. C. Zenz,[147] A. Zuranski,[147] E. Brownson,[148] A. Lopez,[148] H. Mendez,[148] J. E. Ramirez Vargas,[148] E. Alagoz,[149] V. E. Barnes,[149] D. Benedetti,[149] G. Bolla,[149] D. Bortoletto,[149] M. De Mattia,[149] A. Everett,[149] Z. Hu,[149] M. Jones,[149] O. Koybasi,[149] M. Kress,[149] A. T. Laasanen,[149] N. Leonardo,[149] V. Maroussov,[149] P. Merkel,[149] D. H. Miller,[149] N. Neumeister,[149] I. Shipsey,[149] D. Silvers,[149] A. Svyatkovskiy,[149] M. Vidal Marono,[149] H. D. Yoo,[149] J. Zablocki,[149] Y. Zheng,[149] S. Guragain,[150] N. Parashar,[150] A. Adair,[151] B. Akgun,[151] C. Boulahouache,[151] K. M. Ecklund,[151] F. J. M. Geurts,[151] W. Li,[151] B. P. Padley,[151] R. Redjimi,[151] J. Roberts,[151] J. Zabel,[151] B. Betchart,[152] A. Bodek,[152] Y. S. Chung,[152] R. Covarelli,[152] P. de Barbaro,[152] R. Demina,[152] Y. Eshaq,[152] T. Ferbel,[152] A. Garcia-Bellido,[152] P. Goldenzweig,[152] J. Han,[152] A. Harel,[152] D. C. Miner,[152] D. Vishnevskiy,[152] M. Zielinski,[152] A. Bhatti,[153] R. Ciesielski,[153] L. Demortier,[153] K. Goulianos,[153] G. Lungu,[153] S. Malik,[153] C. Mesropian,[153] S. Arora,[154] A. Barker,[154] J. P. Chou,[154] C. Contreras-Campana,[154] E. Contreras-Campana,[154] D. Duggan,[154] D. Ferencek,[154] Y. Gershtein,[154] R. Gray,[154] E. Halkiadakis,[154] D. Hidas,[154] A. Lath,[154] S. Panwalkar,[154] M. Park,[154] R. Patel,[154] V. Rekovic,[154] J. Robles,[154] K. Rose,[154] S. Salur,[154] S. Schnetzer,[154] C. Seitz,[154] S. Somalwar,[154] R. Stone,[154] S. Thomas,[154] M. Walker,[154] G. Cerizza,[155] M. Hollingsworth,[155] S. Spanier,[155] Z. C. Yang,[155] A. York,[155] R. Eusebi,[156] W. Flanagan,[156] J. Gilmore,[156] T. Kamon,[156,jjj] V. Khotilovich,[156] R. Montalvo,[156] I. Osipenkov,[156] Y. Pakhotin,[156] A. Perloff,[156] J. Roe,[156] A. Safonov,[156] T. Sakuma,[156] S. Sengupta,[156] I. Suarez,[156] A. Tatarinov,[156] D. Toback,[156] N. Akchurin,[157] J. Damgov,[157] C. Dragoiu,[157] P. R. Dudero,[157] C. Jeong,[157] K. Kovitanggoon,[157] S. W. Lee,[157] T. Libeiro,[157] I. Volobouev,[157] E. Appelt,[158] A. G. Delannoy,[158] C. Florez,[158] S. Greene,[158] A. Gurrola,[158] W. Johns,[158] P. Kurt,[158] C. Maguire,[158] A. Melo,[158] M. Sharma,[158] P. Sheldon,[158] B. Snook,[158] S. Tuo,[158] J. Velkovska,[158] M. W. Arenton,[159] M. Balazs,[159] S. Boutle,[159] B. Cox,[159] B. Francis,[159] J. Goodell,[159] R. Hirosky,[159] A. Ledovskoy,[159] C. Lin,[159] C. Neu,[159] J. Wood,[159] S. Gollapinni,[160] R. Harr,[160] P. E. Karchin,[160] C. Kottachchi Kankanamge Don,[160] P. Lamichhane,[160] A. Sakharov,[160] M. Anderson,[161] D. A. Belknap,[161] L. Borrello,[161] D. Carlsmith,[161] M. Cepeda,[161] S. Dasu,[161] E. Friis,[161] L. Gray,[161] K. S. Grogg,[161] M. Grothe,[161] R. Hall-Wilton,[161] M. Herndon,[161] A. Hervé,[161] P. Klabbers,[161] J. Klukas,[161] A. Lanaro,[161] C. Lazaridis,[161] R. Loveless,[161] A. Mohapatra,[161] M. U. Mozer,[161] I. Ojalvo,[161] F. Palmonari,[161] G. A. Pierro,[161] I. Ross,[161] A. Savin,[161] W. H. Smith,[161] and J. Swanson[161]

(CMS Collaboration)

[1]*Yerevan Physics Institute, Yerevan, Armenia*
[2]*Institut für Hochenergiephysik der OeAW, Wien, Austria*
[3]*National Centre for Particle and High Energy Physics, Minsk, Belarus*
[4]*Universiteit Antwerpen, Antwerpen, Belgium*
[5]*Vrije Universiteit Brussel, Brussel, Belgium*
[6]*Université Libre de Bruxelles, Bruxelles, Belgium*
[7]*Ghent University, Ghent, Belgium*
[8]*Université Catholique de Louvain, Louvain-la-Neuve, Belgium*
[9]*Université de Mons, Mons, Belgium*
[10]*Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil*
[11]*Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil*

[12a]*Universidade Estadual Paulista, São Paulo, Brazil*
[12b]*Universidade Federal do ABC, São Paulo, Brazil*
[13]*Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria*
[14]*University of Sofia, Sofia, Bulgaria*
[15]*Institute of High Energy Physics, Beijing, China*
[16]*State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing, China*
[17]*Universidad de Los Andes, Bogota, Colombia*
[18]*Technical University of Split, Split, Croatia*
[19]*University of Split, Split, Croatia*
[20]*Institute Rudjer Boskovic, Zagreb, Croatia*
[21]*University of Cyprus, Nicosia, Cyprus*
[22]*Charles University, Prague, Czech Republic*
[23]*Academy of Scientific Research and Technology of the Arab Republic of Egypt, Egyptian Network of High Energy Physics, Cairo, Egypt*
[24]*National Institute of Chemical Physics and Biophysics, Tallinn, Estonia*
[25]*Department of Physics, University of Helsinki, Helsinki, Finland*
[26]*Helsinki Institute of Physics, Helsinki, Finland*
[27]*Lappeenranta University of Technology, Lappeenranta, Finland*
[28]*DSM/IRFU, CEA/Saclay, Gif-sur-Yvette, France*
[29]*Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France*
[30]*Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, Université de Haute Alsace Mulhouse, CNRS/IN2P3, Strasbourg, France*
[31]*Université de Lyon, Université Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucléaire de Lyon, Villeurbanne, France*
[32]*Institute of High Energy Physics and Informatization, Tbilisi State University, Tbilisi, Georgia*
[33]*RWTH Aachen University, I. Physikalisches Institut, Aachen, Germany*
[34]*RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany*
[35]*RWTH Aachen University, III. Physikalisches Institut B, Aachen, Germany*
[36]*Deutsches Elektronen-Synchrotron, Hamburg, Germany*
[37]*University of Hamburg, Hamburg, Germany*
[38]*Institut für Experimentelle Kernphysik, Karlsruhe, Germany*
[39]*Institute of Nuclear and Particle Physics (INPP), NCSR Demokritos, Aghia Paraskevi, Greece*
[40]*University of Athens, Athens, Greece*
[41]*University of Ioánnina, Ioánnina, Greece*
[42]*KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary*
[43]*Institute of Nuclear Research ATOMKI, Debrecen, Hungary*
[44]*University of Debrecen, Debrecen, Hungary*
[45]*Panjab University, Chandigarh, India*
[46]*University of Delhi, Delhi, India*
[47]*Saha Institute of Nuclear Physics, Kolkata, India*
[48]*Bhabha Atomic Research Centre, Mumbai, India*
[49]*Tata Institute of Fundamental Research-EHEP, Mumbai, India*
[50]*Tata Institute of Fundamental Research-HECR, Mumbai, India*
[51]*Institute for Research in Fundamental Sciences (IPM), Tehran, Iran*
[52a]*INFN Sezione di Bari, Bari, Italy*
[52b]*Università di Bari, Bari, Italy*
[52c]*Politecnico di Bari, Bari, Italy*
[53a]*INFN Sezione di Bologna, Bologna, Italy*
[53b]*Università di Bologna, Bologna, Italy*
[54a]*INFN Sezione di Catania, Catania, Italy*
[54b]*Università di Catania, Catania, Italy*
[55a]*INFN Sezione di Firenze, Firenze, Italy*
[55b]*Università di Firenze, Firenze, Italy*
[56]*INFN Laboratori Nazionali di Frascati, Frascati, Italy*
[57a]*INFN Sezione di Genova, Genova, Italy*
[57b]*Università di Genova, Genova, Italy*
[58a]*INFN Sezione di Milano-Bicocca, Milano, Italy*
[58b]*Università di Milano-Bicocca, Milano, Italy*
[59a]*INFN Sezione di Napoli, Napoli, Italy*
[59b]*Università di Napoli 'Federico II', Napoli, Italy*
[59c]*Università della Basilicata (Potenza), Napoli, Italy*
[59d]*Università G. Marconi (Roma), Napoli, Italy*

[60a]*INFN Sezione di Padova, Padova, Italy*
[60b]*Università di Padova, Padova, Italy*
[60c]*Università di Trento (Trento), Padova, Italy*
[61a]*INFN Sezione di Pavia, Pavia, Italy*
[61b]*Università di Pavia, Pavia, Italy*
[62a]*INFN Sezione di Perugia, Perugia, Italy*
[62b]*Università di Perugia, Perugia, Italy*
[63a]*INFN Sezione di Pisa, Pisa, Italy*
[63b]*Università di Pisa, Pisa, Italy*
[63c]*Scuola Normale Superiore di Pisa, Pisa, Italy*
[64a]*INFN Sezione di Roma, Roma, Italy*
[64b]*Università di Roma, Roma, Italy*
[65a]*INFN Sezione di Torino, Torino, Italy*
[65b]*Università di Torino, Torino, Italy*
[65c]*Università del Piemonte Orientale (Novara), Torino, Italy*
[66a]*INFN Sezione di Trieste, Trieste, Italy*
[66b]*Università di Trieste, Trieste, Italy*
[67]*Kangwon National University, Chunchon, Korea*
[68]*Kyungpook National University, Daegu, Korea*
[69]*Chonnam National University, Institute for Universe and Elementary Particles, Kwangju, Korea*
[70]*Korea University, Seoul, Korea*
[71]*University of Seoul, Seoul, Korea*
[72]*Sungkyunkwan University, Suwon, Korea*
[73]*Vilnius University, Vilnius, Lithuania*
[74]*Centro de Investigacion y de Estudios Avanzados del IPN, Mexico City, Mexico*
[75]*Universidad Iberoamericana, Mexico City, Mexico*
[76]*Benemerita Universidad Autonoma de Puebla, Puebla, Mexico*
[77]*Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico*
[78]*University of Auckland, Auckland, New Zealand*
[79]*University of Canterbury, Christchurch, New Zealand*
[80]*National Centre for Physics, Quaid-I-Azam University, Islamabad, Pakistan*
[81]*National Centre for Nuclear Research, Swierk, Poland*
[82]*Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland*
[83]*Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal*
[84]*Joint Institute for Nuclear Research, Dubna, Russia*
[85]*Petersburg Nuclear Physics Institute, Gatchina (St. Petersburg), Russia*
[86]*Institute for Nuclear Research, Moscow, Russia*
[87]*Institute for Theoretical and Experimental Physics, Moscow, Russia*
[88]*P.N. Lebedev Physical Institute, Moscow, Russia*
[89]*Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia*
[90]*State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, Russia*
[91]*University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia*
[92]*Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain*
[93]*Universidad Autónoma de Madrid, Madrid, Spain*
[94]*Universidad de Oviedo, Oviedo, Spain*
[95]*Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander, Spain*
[96]*CERN, European Organization for Nuclear Research, Geneva, Switzerland*
[97]*Paul Scherrer Institut, Villigen, Switzerland*
[98]*Institute for Particle Physics, ETH Zurich, Zurich, Switzerland*
[99]*Universität Zürich, Zurich, Switzerland*
[100]*National Central University, Chung-Li, Taiwan*
[101]*National Taiwan University (NTU), Taipei, Taiwan*
[102]*Chulalongkorn University, Bangkok, Thailand*
[103]*Cukurova University, Adana, Turkey*
[104]*Middle East Technical University, Physics Department, Ankara, Turkey*
[105]*Bogazici University, Istanbul, Turkey*
[106]*Istanbul Technical University, Istanbul, Turkey*
[107]*National Scientific Center, Kharkov Institute of Physics and Technology, Kharkov, Ukraine*
[108]*University of Bristol, Bristol, United Kingdom*
[109]*Rutherford Appleton Laboratory, Didcot, United Kingdom*
[110]*Imperial College, London, United Kingdom*

[111]*Brunel University, Uxbridge, United Kingdom*
[112]*Baylor University, Waco, Texas, USA*
[113]*The University of Alabama, Tuscaloosa, Alabama, USA*
[114]*Boston University, Boston, Louisian, USA*
[115]*Brown University, Providence, Rhode Island, USA*
[116]*University of California, Davis, Davis, California, USA*
[117]*University of California, Los Angeles, Los Angeles, California, USA*
[118]*University of California, Riverside, Riverside, California, USA*
[119]*University of California, San Diego, La Jolla, California, USA*
[120]*University of California, Santa Barbara, Santa Barbara, California, USA*
[121]*California Institute of Technology, Pasadena, California, USA*
[122]*Carnegie Mellon University, Pittsburgh, Pennsylvania, USA*
[123]*University of Colorado at Boulder, Boulder, Colorado, USA*
[124]*Cornell University, Ithaca, New York, USA*
[125]*Fairfield University, Fairfield, Connecticut, USA*
[126]*Fermi National Accelerator Laboratory, Batavia, Illinois, USA*
[127]*University of Florida, Gainesville, Florida, USA*
[128]*Florida International University, Miami, Florida, USA*
[129]*Florida State University, Tallahassee, Florida, USA*
[130]*Florida Institute of Technology, Melbourne, Florida, USA*
[131]*University of Illinois at Chicago (UIC), Chicago, Illinois, USA*
[132]*The University of Iowa, Iowa City, Iowa, USA*
[133]*Johns Hopkins University, Baltimore, Maryland, USA*
[134]*The University of Kansas, Lawrence, Kansas, USA*
[135]*Kansas State University, Manhattan, Kansas, USA*
[136]*Lawrence Livermore National Laboratory, Livermore, California, USA*
[137]*University of Maryland, College Park, Maryland, USA*
[138]*Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*
[139]*University of Minnesota, Minneapolis, Minnesota, USA*
[140]*University of Mississippi, Oxford, Mississippi, USA*
[141]*University of Nebraska-Lincoln, Lincoln, Nebraska, USA*
[142]*State University of New York at Buffalo, Buffalo, New York, USA*
[143]*Northeastern University, Boston, Massachusetts, USA*
[144]*Northwestern University, Evanston, Illinois, USA*
[145]*University of Notre Dame, Notre Dame, Indiana, USA*
[146]*The Ohio State University, Columbus, Ohio, USA*
[147]*Princeton University, Princeton, New Jersey, USA*
[148]*University of Puerto Rico, Mayaguez, Puerto Rico*
[149]*Purdue University, West Lafayette, Indiana, USA*
[150]*Purdue University Calumet, Hammond, Indiana, USA*
[151]*Rice University, Houston, Texas, USA*
[152]*University of Rochester, Rochester, New York, USA*
[153]*The Rockefeller University, New York, New York, USA*
[154]*Rutgers, The State University of New Jersey, Piscataway, New Jersey, USA*
[155]*University of Tennessee, Knoxville, Tennessee, USA*
[156]*Texas A&M University, College Station, Texas, USA*
[157]*Texas Tech University, Lubbock, Texas, USA*
[158]*Vanderbilt University, Nashville, Tennessee, USA*
[159]*University of Virginia, Charlottesville, Virginia, USA*
[160]*Wayne State University, Detroit, Michigan, USA*
[161]*University of Wisconsin, Madison, Wisconsin, USA*

[a]Deceased.
[b]Also at Vienna University of Technology, Vienna, Austria.
[c]Also at CERN, European Organization for Nuclear Research, Geneva, Switzerland.
[d]Also at National Institute of Chemical Physics and Biophysics, Tallinn, Estonia.
[e]Also at California Institute of Technology, Pasadena, CA, USA.
[f]Also at Laboratoire Leprince-Ringuet, Ecole Polytechnique, IN2P3-CNRS, Palaiseau, France.
[g]Also at Suez Canal University, Suez, Egypt.
[h]Also at Zewail City of Science and Technology, Zewail, Egypt.

[i]Also at Cairo University, Cairo, Egypt.
[j]Also at Fayoum University, El-Fayoum, Egypt.
[k]Also at British University in Egypt, Cairo, Egypt.
[l]Now at Ain Shams University, Cairo, Egypt.
[m]Also at National Centre for Nuclear Research, Swierk, Poland.
[n]Also at Université de Haute Alsace, Mulhouse, France.
[o]Also at Joint Institute for Nuclear Research, Dubna, Russia.
[p]Also at Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia.
[q]Also at Brandenburg University of Technology, Cottbus, Germany.
[r]Also at The University of Kansas, Lawrence, KS, USA.
[s]Also at Institute of Nuclear Research ATOMKI, Debrecen, Hungary.
[t]Also at Eötvös Loránd University, Budapest, Hungary.
[u]Also at Tata Institute of Fundamental Research-HECR, Mumbai, India.
[v]Now at King Abdulaziz University, Jeddah, Saudi Arabia.
[w]Also at University of Visva-Bharati, Santiniketan, India.
[x]Also at Sharif University of Technology, Tehran, Iran.
[y]Also at Isfahan University of Technology, Isfahan, Iran.
[z]Also at Shiraz University, Shiraz, Iran.
[aa]Also at Plasma Physics Research Center, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[bb]Also at Facoltà Ingegneria, Università di Roma, Roma, Italy.
[cc]Now at Università degli Studi Guglielmo Marconi, Roma, Italy.
[dd]Also at Università degli Studi di Siena, Siena, Italy.
[ee]Also at University of Bucharest, Faculty of Physics, Bucuresti-Magurele, Romania.
[ff]Also at Faculty of Physics, University of Belgrade, Belgrade, Serbia.
[gg]Also at University of California, Los Angeles, CA, USA.
[hh]Also at Scuola Normale e Sezione dell'INFN, Pisa, Italy.
[ii]Also at INFN Sezione di Roma, Roma, Italy.
[jj]Also at University of Athens, Athens, Greece.
[kk]Also at Rutherford Appleton Laboratory, Didcot, United Kingdom.
[ll]Also at Paul Scherrer Institut, Villigen, Switzerland.
[mm]Also at Institute for Theoretical and Experimental Physics, Moscow, Russia.
[nn]Also at Albert Einstein Center for Fundamental Physics, Bern, Switzerland.
[oo]Also at Gaziosmanpasa University, Tokat, Turkey.
[pp]Also at Adiyaman University, Adiyaman, Turkey.
[qq]Also at Izmir Institute of Technology, Izmir, Turkey.
[rr]Also at The University of Iowa, Iowa City, USA.
[ss]Also at Mersin University, Mersin, Turkey.
[tt]Also at Ozyegin University, Istanbul, Turkey.
[uu]Also at Kafkas University, Kars, Turkey.
[vv]Also at Suleyman Demirel University, Isparta, Turkey.
[ww]Also at Ege University, Izmir, Turkey.
[xx]Also at Mimar Sinan University, Istanbul, Istanbul, Turkey.
[yy]Also at Kahramanmaras Sütcü Imam University, Kahramanmaras, Turkey.
[zz]Also at School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom.
[aaa]Also at INFN Sezione di Perugia, Università di Perugia, Perugia, Italy.
[bbb]Also at Utah Valley University, Orem, UT, USA.
[ccc]Also at University of Edinburgh, Scotland, Edinburgh, United Kingdom.
[ddd]Also at Institute for Nuclear Research, Moscow, Russia.
[eee]Also at University of Belgrade, Faculty of Physics and Vinca Institute of Nuclear Sciences, Belgrade, Serbia.
[fff]Also at Argonne National Laboratory, Argonne, IL, USA.
[ggg]Also at Erzincan University, Erzincan, Turkey.
[hhh]Also at Yildiz Technical University, Istanbul, Turkey.
[iii]Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary.
[jjj]Also at Kyungpook National University, Daegu, Korea.